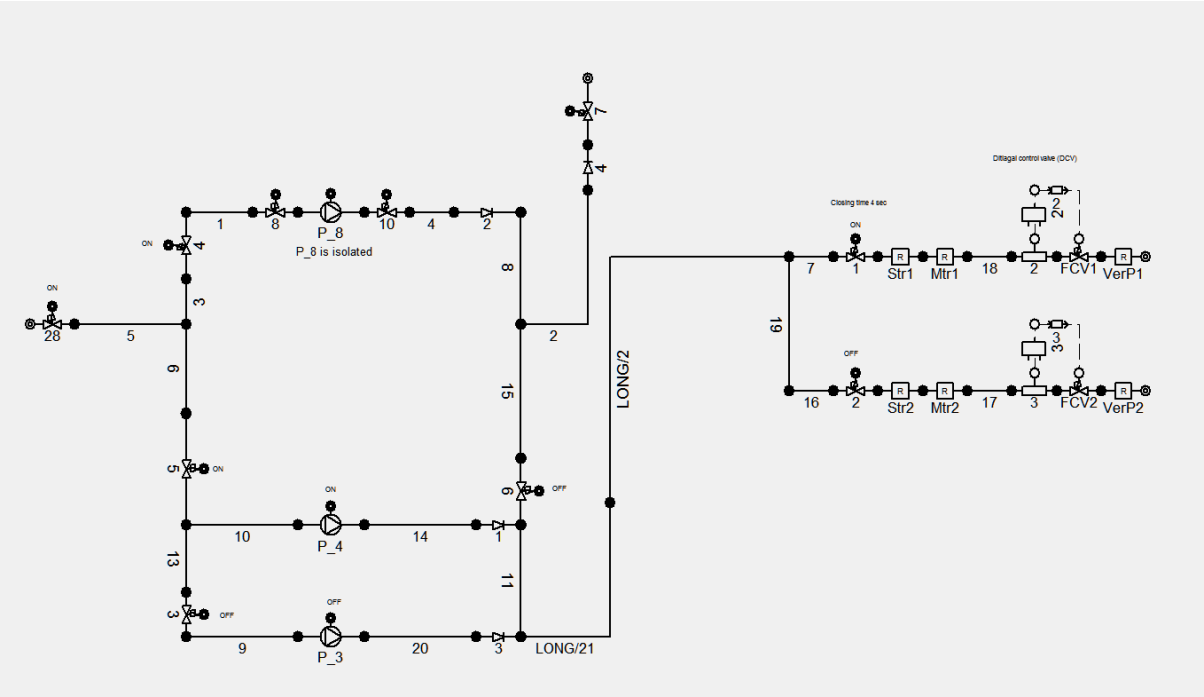
Application Bulletin – Oil & Gas Industry
PIPENET® Transient Module Case Study

SENSITIVITY ANALYSIS OF THE CONTROL SYSTEM ON A PIPELINE

BACKGROUND

The network has 3 pumps of which one pump is running at its design speed in this scenario. The other two pumps are shut down. The system has two flow control valves which are identical. The scenarios below consider the response of the control valve to one of the isolation valves closing. The isolation valve which is closing is valve 2.

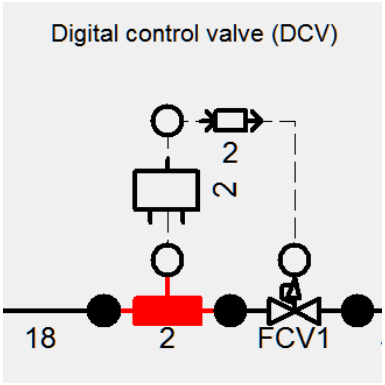
1. The network.



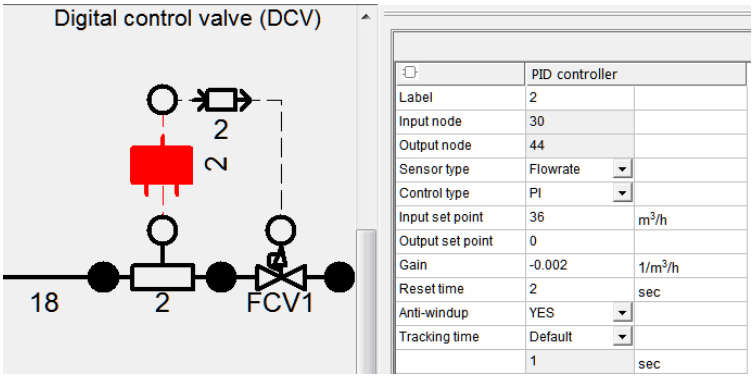
2. The control system.

PIPENET has comprehensive capabilities for building control systems including loops such as cascade control, signal selector, switches and so on. In this network the control system is built using a flow sensor, PID controller, first order transfer function, and the control valve.

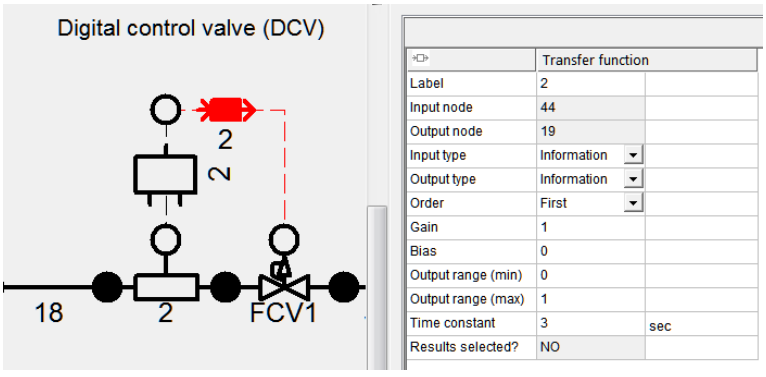
Flow sensor: Flow sensor 2 is in-line with pipe 18. It is selected to be of the analogue type. For this reason, there is no sampling time.



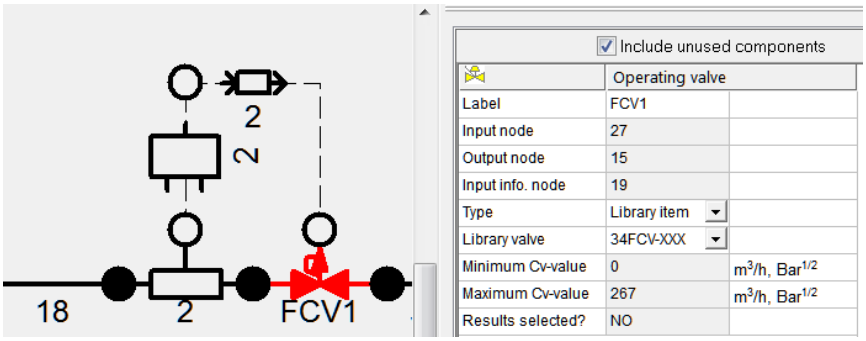
The PID controller is selected to be of the PI type. The parameters are shown in the dialog box below.



The transfer function model shown below represents the dynamics of the control valve. In general, a control valve will not respond instantly to a change in the input signal. Typically, the dynamics of this is modelled by using a transfer function. PIPENET offers a choice of zeroth, first and second order transfer functions. In this model the first order transfer function model is used with a time constant of 3 secs.



The control valve and its characteristics are shown below.

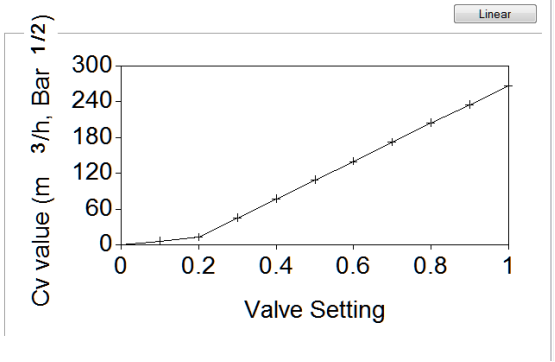


Include unused components

	Operating valve	
Label	FCV1	
Input node	27	
Output node	15	
Input info. node	19	
Type	Library item	
Library valve	34FCV-XXX	
Minimum Cv-value	0	m^3/h, $Bar^{1/2}$
Maximum Cv-value	267	m^3/h, $Bar^{1/2}$
Results selected?	NO	

s-value	Flow Coeff.	dCv/ds
0	0	70
0.4	77	320
0.5	109	315
0.6	140	315
0.7	172	320
0.8	204	315
0.9	235	315
1	267	320

Linear

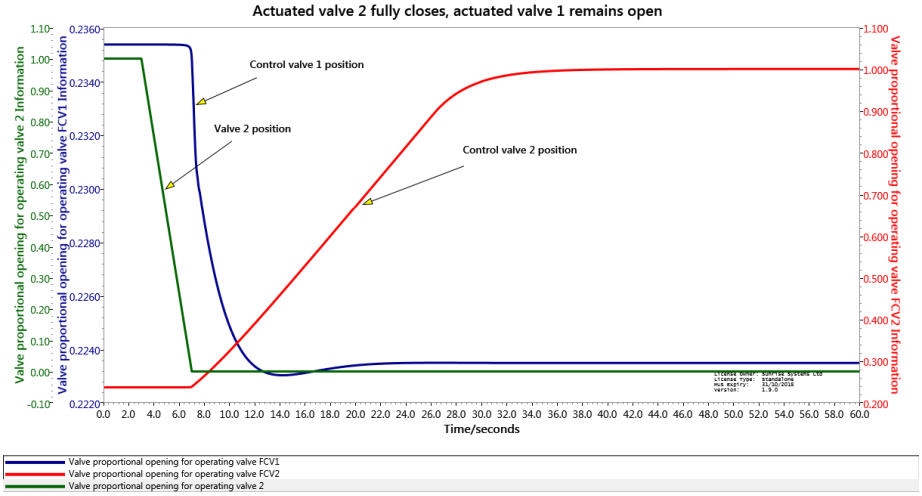


3. The Scenarios.

Three scenarios are considered in this study. The aim is to both understand the behaviour of the system and to make sure that the control system is stable.

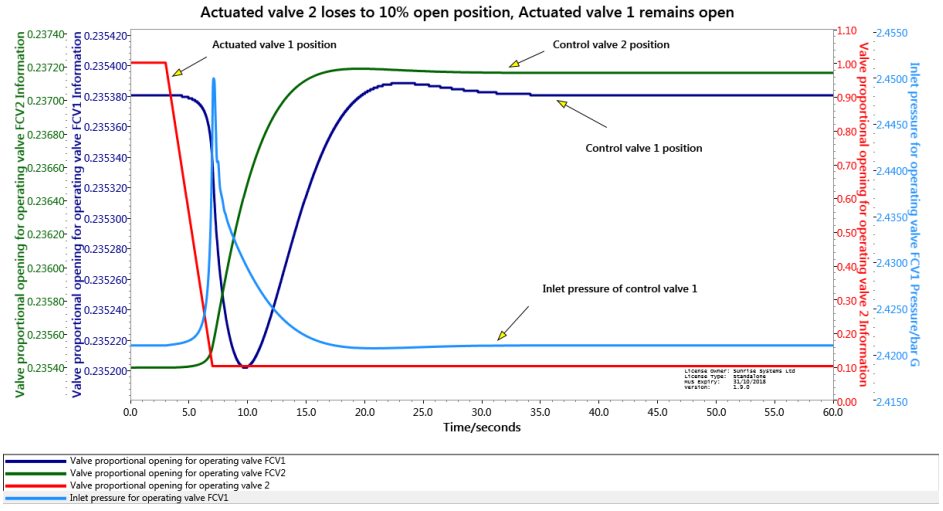
Scenario 1: Actuated valve 2 fully closes, actuated valve 1 remains fully open

We can make the following observations. When the actuated valve 2 closes, the flow is directed towards control valve 1. In order to compensate for this the control valve closes slightly. There is a small overshoot before it comes back to its final steady state position. On the other hand, control valve 2 opens fully. This is because when the actuated valve fully closes, it tries to maintain the flow at its set point. The behaviour of the system is smooth and no instability is observed.



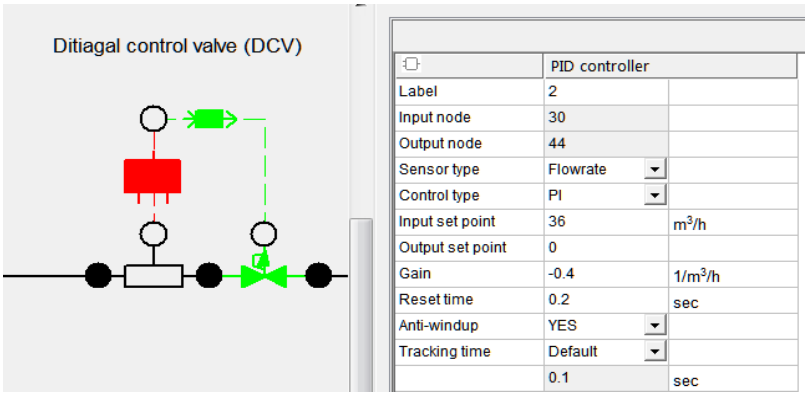
Scenario 2: Actuated valve 2 closes to 10% open position, actuated valve 1 remains fully open

We can make the following observations. When the actuated valve 2 closes to its 10% open position, more flow is directed towards control valve 1. In order to compensate for this the control valve closes slightly. However as the actuated valve does not fully close control valve 2 is able to open sufficiently in order to restore its flow rate to the set point. When this happens, control valve 1 goes back to its original position and the flow is restored. The behaviour of the system is smooth and no instability is observed.



Scenario 3: Actuated valve 2 closes to 10% open position, actuated valve 1 remains fully open with faster control system

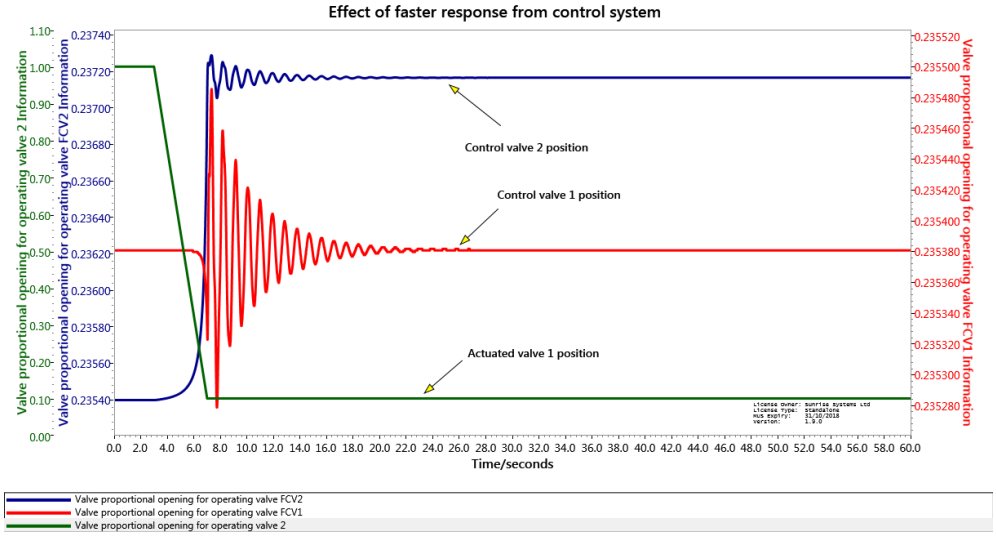
The PID controller parameters are shown below.



	PID controller	
Label	2	
Input node	30	
Output node	44	
Sensor type	Flowrate	
Control type	PI	
Input set point	36	m^3/h
Output set point	0	
Gain	-0.4	$1/m^3/h$
Reset time	0.2	sec
Anti-windup	YES	
Tracking time	Default	
	0.1	sec

We can make the following observations. The basic behaviour is similar to scenario 2. When the actuated valve 2 closes to its 10% open position, more flow is directed towards control valve 1. In order to compensate for this the control valve closes slightly. However, as the actuated valve does not fully close control valve 2 is able to open sufficiently in order to restore its flow rate to the set point. When this happens, control valve 1 goes back to its original position and the flow is restored.

The main point to note however is that the system is unstable and there are oscillations in the valve position.



CONCLUSIONS

If you have any questions about this case study, or any other of PIPENET's capabilities, please email us at Pipenet@sunrise-sys.com.

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